Courses

Mustapha AIT ALI

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Chemistry of 2D-nanomaterials: Silicene and phosphorene

2D materials are atomically thin sheets that exhibit unique electronic, optical and mechanical properties with remarkable potential for technological applications and a plethora of unexplored fundamental science. For example, graphene is the prototypical 2D material, exhibiting high charge carrier mobilities, chemical inertness and high mechanical strength. Although many bulk materials exhibit layered structures with quasi 2D characteristics, 2D materials are defined here as those composed of one to several (generally, 10 or less) discrete, atomically thin layers that are weakly interacting, often through van der Waals forces. The superlative physical properties of 2D materials arise from the intrinsic chemical properties of their constituent elements, which are incorporated into covalently bonded structures of particular symmetry and low (that is, 2D) dimensionality. The chemically sim¬plest cases exist in elemental 2D materials, of which two are known to also occur in bulk layered form: graphene and recently: silicene and phosphorene. Since facile fabrication processes of large area nanosheets are required for practical applications, a development of soft chemical synthesis route without using conventional vacuum processes is a challenging issue. Techniques for the exfoliation of layered compounds are widely used to fabricate nanometer-thick materials, such as oxides, niobates, chalcogenides, phosphates, and graphene. Although a variety of nanosheets have been synthesized, there have been few reports of silicon and phosphor nanosheets. Mass production of silicon and phosphor nanosheets without conventional vacuum processes and vapor deposition can be achieved using low cost top-down approach starting from materials that comprise a 2D sheet structure as a fundamental unit. Chemical processes provide an alternative route to large-scale synthesis of 2D nanomaterials under production conditions. In this perspective, this work focuses on recent progress in chemistry of 2D-nanomaterials:

–Silicene,

–Phosphorene.

Mahmoud AL-HUSSEIN

Physics Department, University of Jordan Amman, Jordan

Revealing the Structure and Morphology of Nanostructured Materials Using Advanced X-ray Scattering Techniques

New materials with controlled structure ranging from nanometer to macroscopic scales are essential for advanced technological applications. Many organic materials self-assemble spontaneously into ordered structures with well defined symmetry and dominant characteristic lengths. However, controlling length scale and precise positioning of the molecular componentsare critical for advanced technological applications. Therefore, scientists are currently attempting to mimic the precision and complexity of many biological materials into synthetic organic materials.On the other hand, a proper characterization of the structure and morphology of such nanostructured materials on the nano scale is key for a better understanding of the structure forming mechanisms and in turn more control of their properties.To this end grazing incidence X-ray scattering is employed to obtain information on both the lateral and vertical order in nanostructured thin films. Specular X-ray reflectivity (XR) measurements is used to probe the electron density profile along the surface normal direction. Lateral ordering is studied using grazing incidence small and wide angle X-ray scattering (GISAXS and GIWAXS). Within this context, the following topics will be addressed in my lectures:

–An introduction to the principles of advanced X-ray scattering techniques used to characterize order in thin films.

–Representative examples will be discussed using organic nanostructured materials having nanotechnological applications.

Mustafa BENYOUCEF

FST, Cadi Ayyad University, Marrakech, Morocco

Single Crystal Ni-base Superalloys From the Microstructure to the Outstanding Properties

The evolution of the chemical composition and the progress made in the manufacturing processes of superalloys enabled the development of the aeronautics industry. The increase in the content of refractory elements such as W, Ta and Mo, gave birth to the first generation of superalloys. Progressive introduction of Re, up to 6 %, by General Electric, Pratt & Whitney and Cannon Muskengon was a major step in the improvement of creep resistance at high temperature of second and third generation.

In this course we present the different generations of single crystal superalloys with an emphasis on the developments made int he conception and design of these alloys in order to fulfill the need of the aeronautics industry. We will focus on the high temperature mechanical behavior of these industrial alloys which is directly related to their microstructure. Hence the importance of understanding the formation and aging of the microstructure. Particularly for aeronautical superalloys used in the manufacturing of the hottest parts of turbo-engines. The optimization of the microstructure of superalloys allows the development of alloys with high thermo-mechanical resistance (temperatures reaching 1100°C and loads of 150MPa). The use of high temperatures at the entry of the turbine slows the decrease of oil consumption.

The outstanding mechanical properties of these alloys are mainly due to their particular microstructure, formed by γ' precipitates (L12 ordered structure) impeded in a γ matrix (FCC disordered structure). The γ' precipitates act as a barriers to the dislocation propagation. These dislocations are the origin of the irreversible deformation of metallic materials. Initially, the γ' precipitates have a cuboidal shape, and sizes of hundreds of nanometers with a volume fraction between 60 and 70%.

During service, the microstructure of superalloys is subject to morphology changes leading to an oriented coalescence, called rafting, driven by an important plastic activity with dense interfacial dislocations at the γ/γ' interface. When the rafted structure becomes unstable, it leads to the rupture of the material. Therefor, it is important to understand and control the formation and evolution of this rafted structure in superalloys.

These topics will be treated in this course I order to understand the exceptional mechanical behavior of superalloys at high temperature.

Christian BROSSEAU

University of Brest, France

Matériaux composites: Ingénierie et Propriétés de Transport Électromagnétique

La complexité des matériaux composites requiert généralement une analyse multi-échelle des propriétés physiques, physicochimiques, et structurales. Deux aspects sont évoqués: (i) Quel peut être l'apport des simulations numériques d'hétérostructures pour la prédiction des propriétés diélectriques effectives?; (ii) Est-ce que les relations micro/macro sont adaptées à la modélisation et à la caractérisation des propriétés électromagnétiques de nanostructures?

Luis Cadillon COSTA

I3N, Physics Department, University of Aveiro, Portugal

Impedance spectroscopy: physical concepts and applications

Impedance spectroscopy is a powerful technique that permits to understand the polarization mechanisms in materials, that is, the charge migration and that one due to the orientation of permanent dipoles. To obtain a complete characterization of the dielectric response, a large range of frequencies and temperatures must be used. The different regimes of the dielectric function can be observed, and the dynamics of the relaxations can be found. In this talk, different examples of using impedance spectroscopy to characterize materials are presented, showing the capability of this technique. It offers performances that permit to investigate the fundamental aspects of the electrical properties, yielding a wealth of information about the molecular motions and relaxation processes present in the materials.

Zineb GUENNOUNI

ECE PARIS & Université Pierre et Marie Curie, France

Matériaux polymères : Structures et propriétés en solution et aux interfaces

Les polymères sont des matériaux omniprésents, qui s'imposent à nous dans tous les domaines de nos activités quotidiennes. D'origine naturelle ou d'origine synthétique, ces macromolécules ont des propriétés remarquables du point de vue microscopique et/ou macroscopique. La multitude des degrés de liberté de leurs monomères leurs confère un grand nombre de conformations possibles et complexes qui dépendent des différents paramètres physicochimiques. Nous présenterons dans ce cours les différents types de polymères, certaines de leurs propriétés et leur comportement dans différents environnements. Nous passerons également en revue quelques avancées scientifiques, les applications actuelles et potentielles dans différents secteurs d'utilisations de ces matériaux novateurs.

Manuel Pedro Fernandes GRAÇA

I3N, Physics Department, University of Aveiro, Portugal

Glasses and glass-ceramics, preparation methods versus applications

Glasses, glass-ceramics, and ceramics are essential materials for the humanity, having a constant presence in day-to-day and contributing to a better way of life for many people. Those materials are used on a wide range of applications, from everyday objects, art, decoration, among many others, expanding to scientific and technological areas like microelectronics, power electronics, physics, including nuclear physics, optical telecommunications, etc. All of this is possible due to the different physical and chemical properties that can be tune in these materials, particularly in glasses. Besides the control of the chemical composition, the preparation method is crucial. Although glasses and ceramics can be presented as different materials, they are strongly correlated. The key to their success is mainly the production methods applied during its manufacture. So, it is essential to know and study the techniques implemented in their production, as well as their relation to the properties presented by the material as a final product. In this course, a description of the glass preparation processes, namely melt-quenching and sol-gel, will be presented. Techniques for the promotion of crystal particles grow on such glasses, like thermal, thermoelectric and thermomagnetic treatments will be presented.

Ahmed IHLAL

Sciences Faculty, Ibn Zohr University, Agadir, Morocco

Conversion photovoltaïque: de l'atome au système PV

L'électricité photovoltaïque constitue aujourd'hui une alternative économiquement viable pour lutter contre le réchauffement climatique. En effet, la parité réseau est atteinte dans plusieurs régions du monde. Il existe aujourd'hui plusieurs générations de cellules solaires. Le but de ce cours est passer en revue ces quatre générations. Un accent particulier sera mis sur la première et la deuxième génération de cellules PV. On y abordera l'état de l'art des différentes filières. Puis on s'intéressera aux systèmes PV. On s'intéressera plus particulièrement à l'évaluation des facteurs qui limitent les performances des installations PV. Un bref aperçu des aspects économiques sera également abordé.

Mustapha MABROUKI

Faculté des Sciences et Techniques Béni Mellal, Morocco

La microscopie à force atomique du principe de fonctionnement à l'exploitation des images

La microscopie à force atomique (AFM) est une technique d'imagerie à balayage de sonde qui permet de cartographier les interactions entre une pointe fine et une surface ou des objets supportés. Beaucoup de paramètres (forme et nature de pointe, portée des forces d'interaction, etc…) influencent la résolution. Bien que l'on puisse voir des défauts atomiques ponctuels, la technique est très largement utilisée à résolution moindre ou basse. La palette de modes d'acquisition et d'échantillons observables est très riche. L'exploitation des résultats est d'une importance capitale pour les jeunes chercheurs et les doctorants. Le présent cours mettra l'accent sur les outils d'analyses et d'interprétation des images obtenue par AFM dans l'air et les liquides.

Abdelkader OUTZOURHIT

Cadi Ayyad University, Marrakech, Morocco

Advanced Materials for Energy Conversion, Harvesting, and Storage

In this course we will present an over view of energy conversion, harvesting and storage techniques as well as the materials used there in. These include, solar energy (both PV and solar thermal), thermoelectric, piezoelectric, electrochemical, bioenergy conversion as well asfuel cells. In addition, various energy storage techniques will also be presented. The state of the art as well as research path ways will be discussed. A special focus will be put on semiconductor materials and hybrid materials for solar cells and photo-thermal conversion, thermoelectric materials, piezoelectric materials, electrodes for advanced batteries and super-capacitors.

Tamara PETKOVA

Bulgarian Academy of Sciences, Sofia, Bulgaria

Plamen PETKOV

University of Chemical Technology and Metallurgy, Sofia, Bulgaria

Advanced chalcogenide and oxide materials for multifunctional applications

Materials play an important role in progress of science and engineering. Throughout the world there is a large need for new types of materials. Materials used today are not available anymore or become too expensive. New materials are necessary also because of the limiting of the physical properties of the present materials .Two type of materials are presented non-oxide (chalcogenide) and oxide materials.Bulk chalcogenide glasses are prepared with melt-quenched technique are studied with respect to their properties – density, microhardness, compactness as a function of the composition. The biggest changes in the structure (higher sensitivity) are expected in the less compact sample, i.e. having flexible structure. Thermal characteristics are obtained from the calorimetric investigations. The sorption properties of thin chalcogenide films are studied upon exposure to water, ethanol, acetone and ammonia vapours. The phase transition in films has been investigated using the temperature dependent sheet resistance method. The dependence of the resistance from the composition and temperature has been discussed. A standard optical recording was demonstrated in thin films with diffraction efficiency strongly depending on the composition. Very often the use of composite materials results in lighter weight, better functionality and provides greater environmental resistance (against, e.g., corrosion) than their compound counterparts. Low-cost composites are therefore being considered as beneficial materials in many areas. The preparation of oxides using various techniques (melt-quenching, sol-gel, hydrothermal, precipitation) is presented. The synthesis conditions are of great importance for the materials properties and performances. The materials characterizations both physic chemical and electrochemical demonstrate the opportunities for materials application in the practice.

Cyril POPOV

Kassel University, Germany

Characterization of basic and application relevant properties of thin diamond films: Principles and examples

The comprehensive characterization of the basic and application relevant properties of bulk materials and thin films requires the application of a number of complementary analytical techniques. The lecture course will present an overview of techniques for characterization of the topography, morphology, structure, crystallinity, composition and chemical bonding structure of materials, including Atomic Force Microscopy (AFM)White Light Interferometry (WLI)Scanning Electron Microscopy (SEM)Transmission Electron Microscopy (TEM)Electron Energy Loss Spectroscopy (EELS)X-ray Diffraction (XRD)X-ray Reflectivity (XRR)Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS) Secondary Ion Mass Spectrometry (SIMS)Fourier Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy Nuclear Reaction Analysis (NRA). The basic principle of each technique will be presented together with examples for characterization of diamond and different diamond films. The analysis of some application relevant properties, such as mechanical (hardness, adhesion, friction), optical (transmission, optical constants), and biological will be also presented and discussed.

Asma TRIKI

LaMaCoP, Département de Physique, Faculté des Sciences de Sfax, Université de Sfax, Tunisia

Apport des analyses diélectriques dans la science des matériaux

La caractérisation diélectrique de divers types de matériaux diélectriques à l'aide d'un pont d'impédance peut s'avérer d'une importance certaine dans la science des matériaux. Ceci contribue à l'amélioration de leurs conceptions. La caractérisation diélectrique est basée sur la polarisation du matériau de l'étude soumis à un champ électrique alternatif dans la gamme de fréquence 0,1 Hz-1 MHz. Des relaxations diélectriques d'origines différentes peuvent alors être observées sur les variations isothermes du facteur de perte ou de la partie imaginaire du module électrique dans des gammes de températures bien déterminées. Les conditions expérimentales de cette caractérisation diélectrique dépendent de la nature du matériau analysé. Dans ce cours, nous analyserons les propriétés diélectriques obtenues pour des bio-composites, des céramiques de types pérovskites et des céramiques poreuses saturées en eau pour des divers objectifs. Dans ces analyses, nous avons eu recours au modèle empirique de Havriliak-Négami.